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# PATENT SPECIFICATION

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## COMPLETE SPECIFICATION

### Improvements in and relating to Articles of Clothing Impervious to X-Rays and Beta-Rays

We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, of Imperial Chemical House, Millbank, London, S.W.1, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This article relates to improvements in and relating to articles of clothing, and relates more particularly to articles of clothing which are impervious to X-rays and beta rays.

15 An object of this invention is to provide an article of clothing which is impervious to X-rays and beta rays and also to liquids, particularly water, and yet permits the passage of gases and 20 vapours therethrough so that aeration and evaporation of moisture from the skin may take place.

This object is accomplished according to the present invention by the provision 25 of an article of clothing made up at least in part by a layer or layers of pliable porous plastic material as hereinafter defined, in which is or are incorporated one or more substances which absorb 30 X-rays and/or beta rays.

The expression "a layer of porous plastic material" is used throughout this specification to denote a layer of plastic material containing a multiplicity of 35 holes between 0.3 and 10 microns in diameter extending through the thickness of the layer, such, for example, as may be produced by the methods hereinafter described, and is not intended to include 40 within its scope cellular material of a

foam- or sponge-like nature, (i.e. material containing gas pockets) which is made, for example, by the liberation of gas from gas-evolving substances occluded therein.

45 The preferred plastic materials for use in the practice of this invention are polyvinyl chloride and polythene because of their toughness, and the ease with which they may be fabricated in pliable, porous sheet form. Other suitable plastic materials include polyvinyl acetate, polymethyl methacrylate, vinyl chloride copolymers with vinyl acetate, vinylidene chloride or diethyl fumarate, nylon, N-alkoxymethyl derivatives of linear polyamides, highly polymeric polymethylene terephthalates, cellulose acetate and ethyl cellulose. In order to achieve a desired degree of flexibility it 50 may be necessary for the plastic material to contain a plasticiser or plasticisers, which should be non-toxic and non-migratory, for example dibutyl phthalate, tricresyl phosphate, higher alkyl 55 phthalates such as di-2-ethyl-hexyl phthalate and dinonyl phthalates, and polyester plasticisers such as those described in British Patent Specification No. 624,393.

70 Substances which absorb X-rays and/or beta rays suitable for the practice of the invention include compounds of elements having high atomic number and in some cases the elements themselves, for 75 example barium sulphate, barium nitrate, bismuth oxide, lead oxide, lead iodide, lead carbonate, and finely divided lead.

The substance or substances which 80

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absorb X-rays and/or beta rays will be incorporated with the plastic material before it is formed into film or sheet form.

5 The article of clothing is preferably made up with two layers of textile fabric between which there is the layer of pliable porous plastic material. In this case it may be made up from a laminate of 10 porous plastic material and textile fabric or it may be made up from separate sheets of these materials which are subsequently stuck together at one or more places. In the former case the plastic material may be given its porosity before incorporation in the laminate. If the plastic and textile fabric sheets are to be stuck together over substantially the whole of their adjoining surfaces, however, it may be difficult to retain the porosity of the plastic material, and in this case, therefore, it is preferred that the material be given its porosity after incorporation in the laminate.

25 When the article of clothing consists of the layer of plastic material alone, or when a laminate is to be used in which the plastic material is to be porous before incorporation in the laminate the desired 30 degree of porosity may be obtained by any suitable process, such as, for example, by electrical perforation of the sheet as described in British Patent Specification Nos. 558,834; 569,968 35 and 614,365, or by incorporation with the plastic material before it is formed into sheets of a solid substance which can subsequently be removed, for example by dissolving out, forming the material into 40 sheet, and removing the incorporated substance, for example as described in British Patent Specifications Nos. 524,063; 565,022; 576,657; 576,658 and 576,659. The porous sheet of plastic 45 material is then made up into the article of clothing or, where a laminate is being used stuck to the textile fabric at one or more places, for example around the edges and/or at various small areas 50 and/or along a series of lines which may cross each other at various points, and then made up. One particularly convenient method is to stick the components of the laminate together along a number 55 of equally spaced parallel straight lines and along another series of equally spaced parallel straight lines at right-angles thereto.

The sticking may be accomplished by 60 means of adhesives, by solvent-softening or by heat-softening applied where sticking is required.

When a laminate is used in which the plastic material is to be made porous 65 after incorporation into the laminate the

required degree of porosity is best obtained by previously incorporating in the plastic material a substance which can be removed subsequently, for example by dissolving-out, forming the plastic material into sheet form, laminating to the textile fabric and removing the incorporated substance. This method is particularly suitable where the plastic material is polythene or polyvinyl chloride. Suitable substances which can be incorporated in the plastic material and subsequently removed include sodium chloride, which can be removed by dissolving out with water, and starch or 70 dextrin which can be removed by means of hot water, sulphuric acid, or malt diastase. Polythene, containing a substance subsequently removable, is conveniently incorporated into the laminate, 75 by coating a sheet of textile fabric with the polythene composition in accordance with one of the methods described in British Patent Specifications Nos. 491,804 and 600,687. the free surface of the 80 polythene film or sheet then being laminated to a further sheet of textile fabric by means of heat and pressure, and the removable substance removed.

Alternatively to the use of a preformed 85 laminate of porous plastic and textile fabric the porous plastic material may be placed between the layers of textile fabric during manufacture of the article of clothing, the layers being subsequently 90 sealed together and the porosity of the plastic material being obtained before or after manufacture as described above in connection with the manufacture of 95 porous plastic material/textile fabric laminate.

A particularly convenient method is to seal the layers of plastic material and textile fabric together at the edges and 100 seams of the article of clothing. In this 105 way stitching of the article of clothing may, if desired, be partially or completely dispensed with.

The textile fabric which is used to 110 make a laminate or for use in making clothes in any other way according to this invention will be dependent to a great extent on the type of article being made. Examples of suitable textile fabrics for clothes, are fabrics made from 115 cotton, wool, felt, linen and synthetic fibres. Leather is also suitable for making certain clothes and for footwear. Wood might also be used for the making 120 of footwear.

When making capes it is not necessary 125 to use a laminate, the cape may be made up from one layer of porous plastic material.

Whenever the article of clothing is to 130

be worn next to the skin or almost next to the skin it is preferable to use a laminate with a layer of textile fabric on the inside of the article. This will ensure that whatever perspiration does not evaporate through the porous plastic material is absorbed by the textile material so that there is no feeling against the skin of wetness or coldness.

10 By wearing articles of clothing according to this invention when working on X-ray machines and in places of atomic research a quite high degree of protection may be obtained with a minimum of discomfort. The normal protection against such radiations is a minimum thickness of metal or metal compound, which naturally makes protective garments heavy and unwieldy. Protective garments according to the present invention are conspicuous in that they may be worn without discomfort for long periods of time. Although they are still heavy due to the incorporation in them of an absorptive substance or substances, they allow the evaporation or perspiration from the skin, thereby reducing fatigue.

PROVISIONAL SPECIFICATION  
**Improvements in and relating to Articles of Clothing Impervious to X-Rays and Beta-Rays**

We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, of Imperial Chemical House, Millbank, London, S.W.1, a British Company, do hereby declare the nature of this invention to be as follows:—

This invention relates to improvements in and relating to articles of clothing, and has for its object the provision of an article of clothing which shall be impervious to X-rays and other radiations harmful to the human body and yet will permit the passage of gases and vapours therethrough so that aeration and evaporation of moisture from the skin may take place. Other objects will appear hereinafter.

These objects are accomplished according to the present invention by the provision of an article of clothing made up at least in part by a layer or layers of pliable porous plastic material containing one or more substances which absorb X-rays and/or other radiation harmful to the human body.

The pore size of the porous plastic material should be such as to prevent the passage of liquids, such as water, while permitting the passage of gases and vapours and so allowing aeration and evaporation of moisture from the skin.

The preferred plastic materials for use in the practice of this invention are polyvinyl chloride and polythene because of their toughness and the ease with which

What we claim is:—

1. An article of clothing made up at least in part by a layer or layers of 30 pliable porous plastic material, as hereinbefore defined, in which is or are incorporated one or more substances which absorb X-rays and/or beta rays.

2. An article of clothing according to 35 Claim 1 made up of a laminate comprising one or more sheets of porous plastic material and one or more textile fabrics.

3. An article of clothing according to 40 Claim 1 or Claim 2 in which the pliable porous plastic material is porous polyvinyl chloride.

4. An article of clothing according to 45 Claim 1 or Claim 2 in which the pliable porous plastic material is porous poly-

5. An article of clothing according to 50 any of the preceding claims in which the pliable porous plastic material contains a plasticiser.

6. An article of clothing substantially as described hereinbefore.

J. W. RIDSDALE,  
 Solicitor for the Applicants.

they may be fabricated in pliable, porous sheet form. Other suitable plastic materials include polyvinyl acetate, polymethyl methacrylate, vinyl chloride 90 copolymers with vinyl acetate, vinylidene chloride or diethyl fumarate, nylon, N-alkoxymethyl derivatives of linear polyamides, highly polymeric polymethylene terephthalates, cellulose acetate and ethyl cellulose. In order to achieve a desired degree of flexibility it may be necessary for the plastic material to contain a plasticiser or plasticisers, for example, dibutyl phthalate, tricresyl phosphate, 100 higher alkyl phthalates such as di-2-ethylhexyl phthalates and dinonyl phthalates, and polyester plasticisers such as those described in British Patent Specification No. 624,393.

105 Substances which absorb X-rays and other radiations suitable for the practice of the invention include compounds of elements having high atomic number and in some cases the elements themselves. 110 for example barium sulphate, barium nitrate, bismuth oxide, lead oxide, lead iodide, lead carbonate, and finely divided lead.

The substance or substances which 115 absorb X-rays or other radiations will be incorporated with the plastic material before it is formed into film or sheet form.

The article of clothing is preferably made up with two layers of textile fab- 120

ric between which there is the layer of pliable porous plastic material. In this case it may be made up from a laminate of porous plastic material and textile fabric or it may be made up from separate sheets of these materials which are subsequently stuck together at one or more places. In the former case the plastic material may be given its porosity before incorporation in the laminate. If the plastic and textile fabric sheets are to be stuck together over substantially the whole of their adjoining surfaces, however, it may be difficult to retain the porosity of the plastic material, and in this case, therefore, it is preferred that the material be given its porosity after incorporation in the laminate.

When the article of clothing consists of the layer of plastic material alone, or when a laminate is to be used in which the plastic material is to be porous before incorporation in the laminate the desired degree of porosity may be obtained by any suitable process, such as, for example, by mechanical piercing of the plastic material in sheet form, by electrical perforation of the sheet as described in British Patent Specifications Nos. 20 558,834; 569,968 and 614,365, or by incorporation with the plastic material before it is formed into sheet a solid substance which can consequently be removed for example by dissolving out, forming the material into sheet, and removing the incorporated substance, for example as described in British Patent Specifications Nos. 30 524,063; 565,022; 576,657; 576,658 and 576,659. The porous sheet 40 of plastic material is then made up into the article of clothing or, where a laminate is being used stuck to the textile fabric at one or more places, for example around the edges and/or at various small 45 areas and/or along a series of lines which may cross each other at various points, and then made up. One particularly convenient method is to stick the components of the laminate together along a number 50 of equally spaced parallel straight lines and along another series of equally parallel straight lines at right-angles thereto.

The sticking may be accomplished by means of adhesives, by solvent-softening 55 or by heat-softening applied where sticking is required.

When a laminate is used in which the plastic material is to be made porous after incorporation into the laminate, the 60 required degree of porosity is best obtained by previously incorporating in the plastic material substance which can be removed subsequently, for example by dissolving-out, forming the plastic material into sheet form, laminating to the textile fabric and removing the incorporated substance. This method is particularly suitable where the plastic material is polythene or polyvinyl chloride. Suitable substances which can be incorporated in the plastic material and subsequently removed include sodium chloride, which can be removed by dissolving out with water, and starch or dextrin which can be removed by means of hot water, sulphuric acid, or malt diastase. Polythene, containing substance subsequently removable, is conveniently incorporated into the laminate by coating a sheet of textile fabric with the polythene composition in accordance with one of the methods described in British Patent Specifications Nos. 491,804 and 600,687, the free surface of the polythene film or sheet then being laminated to a further sheet of textile fabric by means of heat and pressure, and the removable substance removed.

Alternatively to the use of a preformed laminate of porous plastic and textile fabric the porous plastic material may be placed between the layers of textile fabric during manufacture of the article of clothing, the layers being subsequently sealed together and the porosity of the plastic material being obtained before or after manufacture as described above in connection with the manufacture of porous plastic material/textile fabric laminate.

A particularly convenient method is to seal the layers of plastic material and textile fabric together at the edges and seams of the article of clothing. In this way stitching of the article of clothing may, if desired, be partially or completely dispensed with.

The article of clothing of this invention whilst being resistant to X-rays and/or other radiations harmful to the human body, permit the passage of gases and vapours and thus permit aeration and evaporation of moisture from the skin. The articles of clothing are also impervious to liquids, particularly water.

The articles of clothing of this invention are thus particularly suitable for use as protective clothing where there is danger from exposure to X-rays and other radiations, for example in atomic research.

Dated the 4th day of October, 1949.  
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Solicitor for the Applicants.